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Hemodynamic Consideration for Endoleak and Aneurysm Size Change after the Stent-Graft Application of Aortic Aneurysm

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Abstract

Purpose: In the treatment of aortic aneurysm, endovascular stent-graft application has become an established method of treatment. To observe the outcomes of the procedure as the size change of aneurysm in relation with endoleak, a retrospective analysis was done for the consecutive cases who undertook the procedure.

Materials & Method: Stent-graft was applied to the aortic aneurysm in 33 patients. The location of the aneurysm was thoracic in 11 patients and abdominal in 22 patients. CT angiographic was done for the follow-up evaluation to analyze the aneurysm size and the presence of endoleak. Results: Technical success rate was 97% (32/33). The primary success rate without endoleak was 84% (28/33). The secondary success was 90% (30/33). During the follow-up period of 3 months to 7years and 6months in 26 patients, a secondary endoleak developed in 5 cases. Post-implantation syndrome developed in 17 cases (51%). Among the 14 cases with follow-up imaging data for size, endoleak was negative in 10 cases. The aneurysm decreased in 5 cases, stable in size in 4 cases and enlarged in one case (10%).Among the 4 cases with endoleak positive, the aneurysm enlarged in two cases (50%). Conclusion: In the stent-graft application for aortic aneurysm, there is high chance of decrease of aneurysm size in those cases with endoleak negative. However, the aneurysm may increase and eventually rupture in the cases with endoleak positive. Close observation with CT angiography is necessary for the evaluation for the presence of endoleak and size change.

Introduction

True aortic aneurysm is a dilated lumen 1.5 times or larger than normal diameter of aorta. It is surrounded by full three layers of aortic wall. Upper normal range of aortic root diameter is 3.6cm. That of the ascending aorta 1cm proximal to arch is 3.5cm. That of proximal descending aorta is 2.6cm. Middle descending aorta is 2.5cm and abdominal aorta at the level of renal hila is 2.1 cm (if it is a man in 80's) and 1.5 cm (if it is a woman in 40's) [1].

Thoracic aortic aneurysm can be caused by intimal disease or by secondary degeneration of media. It progresses with mechanical stress and poor nutrition to the wall. It frequently involves the aorta distal to left subclavian artery. In many occasions, there is second aneurysm in the infrarenal abdominal aorta[2].

The incidence of abdominal aortic aneurysm (AAA) is 1-4% of population who is older than 50 years. It develops at infrarenal aorta in 89%. AAA can be diagnosed in those cases with abdominal aorta larger than 3 cm in diameter. The usual growth rate of AAA is 3-7mm/yr in 4-5cm aneurysm. Surgery is recommended for AAA larger than 5 cm in diameter. Risk factors for a rupture of aortic aneurysm are aneurysm size larger than 6 cm, growth of aneurysm more than 1cm/year, and presence of clinical symptoms[3-5].

The long-standing traditional surgical approach to the treatment of abdominal aortic aneurysm is to replace the diseased aorta with a prosthetic graft. Because of the relatively high surgical mortality, a stent-graft has instead been used in patients with high risk factors such as old age or severe cardiac, renal or pulmonary diseases.

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Recently the endovascular treatment became one of the established treatments for aortic aneurysm replacing surgical treatment. Since this treatment offers shorter hospitalization and a shorter convalescent period, it is expected to be more widely accepted in the future, thus avoiding the morbidity and mortality associated with surgery[6,7].

After the successful application of stent-graft, the aneurysm is excluded and the flow may be normalized through the lumen of the stent-graft. In those successful cases, a decrease of aneurysm size may be expected. However, if the procedure is failed with an endoleak after stent-graft application, the aneurysm continues to grow in size to be ruptured eventually. That is why we should make a follow-up evaluation with imaging modalities[8,9].

In this study, we evaluate the size of aneurysm after stent-graft application with CT angiography, and related with morphologic and hemodynamic changes after the management of endoleaks.

Materials and Methods

Subjects

A total of 33 patients undertook stent-graft application for aortic aneurysms in the Department of Radiology, Seoul National University Hospital from July 1995 to March 2003. Among them, males were 25 and females were 8. The mean age was 63 years old with range from 40 to 81 years. The location of the aneurysm was thoracic in 11 patients and abdominal in 22 patients.

The disease criteria of the aortic aneurysm were abdominal aortic aneurysm in 18 patients, penetrating ulcer in 4 cases, Behcet's disease in 4 cases, traumatic aneurysm in 3 cases, saccular aneurysm of descending thoracic aorta in 3 cases and syphilis in one patient.

Stent-graft materials and types

The stent graft was Gianturco zig-zag stent with expanded PTFE graft in 30 patients and nitinol mesh and Dacron graft in 3 patients. The introducing set was 18 to 24F in profile with pushing or pre-loaded type. The type of stent-graft was tubular in 16 patients and bifurcated in 17 patients.

Method of insertion of aortic stent graft

The patient is sedated and an appropriate antibiotics is selected. Skin preparation is done for both inguinal areas. Both femoral arteries are exposed by surgery team. After systemic heparinization with heparin 10,000 unit, thoracoabdominal aortography is done. After evaluation of the angiographic findings, the prepared or pre-loaded stent-graft (20F) is inserted after right femoral arteriotomy. Under the fluoroscopy the stent-graft is deployed at the proper site covering the aneurysmal segment. Post-deployment aortography is undertaken with multi-sidehole catheter.

In the case of bifurcated type, additional left femoral arteriotomy is performed. After selection of left iliac short limb with cobra catheter and guidewire, stent-graft set (14F) is inserted and the stent-graft is deployed with overlap more than one segment of the stent. Post-deployment aortography is done. The delivery sheath is removed and the arteriotomy site is closed by surgery team.

With observation at ICU for 24 hours, antibiotics is routinely recommended. A follow-up evaluation with CT angiography is recommended after 2 weeks. CT angiographic was done for the follow-up evaluation every 6 months thereafter to analyze the aneurysm size and the presence of endoleak.

Definition of terminology

Technical success means a successful insertion of stent graft to aneurysm with endovascular technique. The primary success means a successful exclusion of aneurysm with stent graft without endoleak within 30 days after the procedure. The secondary success means a successful exclusion of aneurysm including cases of successful exclusion of aneurysm after intervention for the primary endoleak. A secondary endoleak means a new endoleak developed after 30 days of the procedure.

Results

Success rate

Delivery was successful technically in 97% (32/33). The primary success rate without endoleak was obtained in 84% (28/33). In the five cases, the primary endoleak was managed with surgical conversion or with intervention in 3 cases. The secondary success was obtained in 90% (30/33).

Follow-up results and complications

The follow-up period was 3 months to 7years and 6months in 26 patients. During the period a secondary

endoleak developed in 5 cases. The aneurysm was regressed completely or decreased in size in 15 cases. The 15 cases were Bechet's disease (4 cases), penetrating ulcer (4cases), AAA (5 cases), trauma (1 case), saccular aneurysm (1 case). Post-implantation syndrome developed in 17 cases (51%). New aneurysm developed in one case of Behcet's disease. There were two cases of 30-day mortality due to infection and traumatic rupture of aneurysm. There was one case of right external iliac thrombosis.

Aneurysm size changes

Among the 26 cases with follow-up evaluation, imaging data for size evaluation were available in 14 cases. Endoleak was negative in 10 cases. One of the typical example is illustrated (Fig. 1).

In one of our cases with endotension the aneurysm continued to increase while there is no evidence of endoleak after coil and glue embolizations (Fig.2).

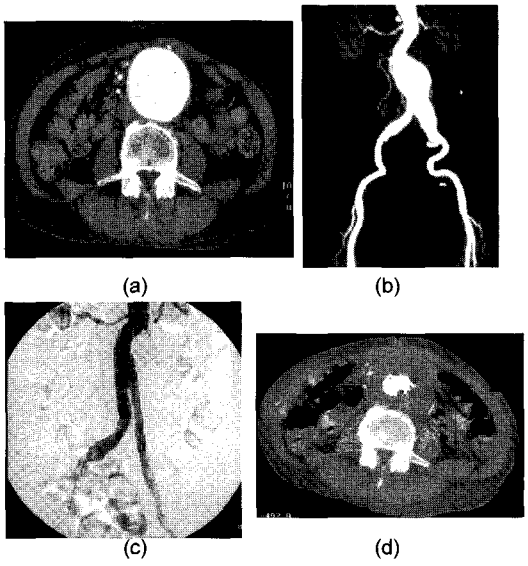

Figure 1. An 81-year-old male with abdominal aortic aneurysm (AAA) treated with stent-graft.

An axial view of CT (Fig. 1a) eveals a markedly dilated AAA. The aneurysm is well demonstrated in the maximum intensity projection CT image (Fig. 1b) After insertion of bifurcated type stent-graft, an immediate follow-up aortography (Fig. 1c)reveals complete exclusion of the AAA. Enhanced CT taken 3 months after (Fig. 1D) reveals complete exclusion of the aneurysm and patent graft lumen with thrombosis of the excluded aneurysm

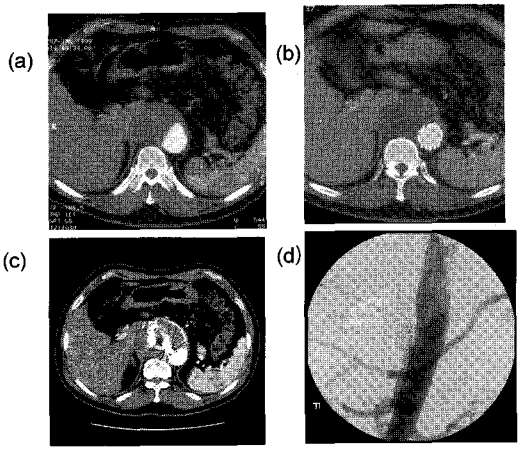

Figure 2. A 59-year-old male with eccentric aneurysm of thoracic aorta treated with stent-graft.

An axial view of CT (Fig. 2a). reveals partially thrombosed aneurysm at thoracoabdominal aorta. After insertion of stent-graft, follow-up CT taken 2 months after the procedure reveals completely thrombosed aneurysm. However, the aneurysm increased continuously. Coil embolization was performed to manage the possible type 1 endoleak. Inspite of the embolization, the aneurysm increased significantly in the follow-up CT taken after 4 years (Fig. 2b). The high densities in the aneurysm are due to the coil and embolic materials. Follow-up aortography (Fig. 2c) reveals no evidence of endoleak, suggestive of endotension. The AP and transverse diameters are plotted along the follow-up period upto 50 months (Fig. 2d). The diameters steadily increased even multiple interventions. In this case, we did eventual surgical conversion after many trials of non-surgical intervention. Endoleak was positive in other 3 cases. One case with endoleak positive is illustrated (Fig. 3). Among the 4 cases with endoleak positive or endotension, the aneurysm enlarged in two cases (50%) and stable or decreased in two cases (Fig. 5). In 6 cases without endoleak the size of aneurysm decreased significantly more than 5 mm.

Discussion

The indications of endovascular management are mostly contraindication to surgery such as old age, associated coronary heart disease or previous major surgery. However, the anatomical indications are also important. Those are aneurysm neck at least longer than 15mm, no reverse taper more than 2mm, a diameter of 26mm or less, no mural thrombus at the fixation site, and aortic angle of aneurysm neck of 60 degree or less [6,7].

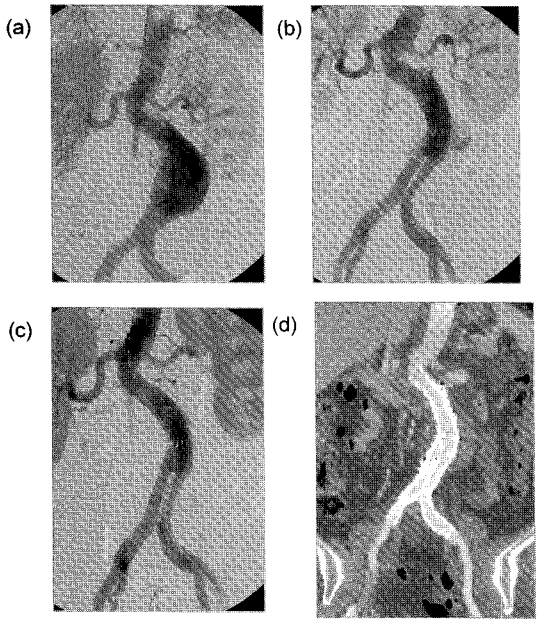

Figure 3. A 71-year-old female with abdominal aortic aneurysm (AAA) treated with stent-graft.

Pre-operative angiography (Fig. 3a) reveals fusiform aneurysm in the infrarenal aorta with severe angulation of the aneurysm neck. After insertion of bifurcated type stent-graft, an immediate follow-up aortography (Fig. 3b) reveals type 1 endoleak at the proximal junction most likely due to the severe angulation of aneurysm neck. An additional stent-graft was applied to the proximal portion to exclude the endoleak. Follow-up aortography (Fig. 3c) and multiplanar reformation CT image (Fig. 3d) show disappearance of the type 1 endoleak suggesting successful exclusion of aneurysm..

Among the 10 cases of endoleak negative group, the aneurysm decreased in 5 cases, stable in size in 4 cases and enlarged in one case (10%) (Fig.4).

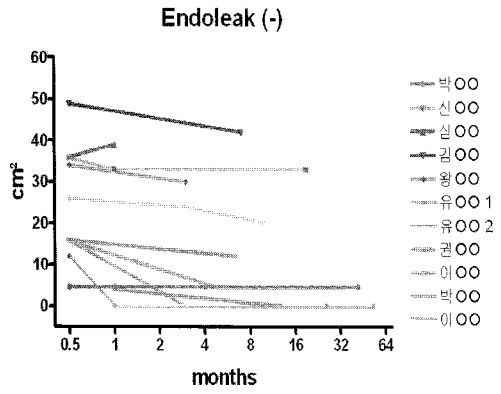

Figure 4. Size changes of aortic aneurysm during the follow-up period in 10 patient with endoleak negative after insertion of stent-graft.

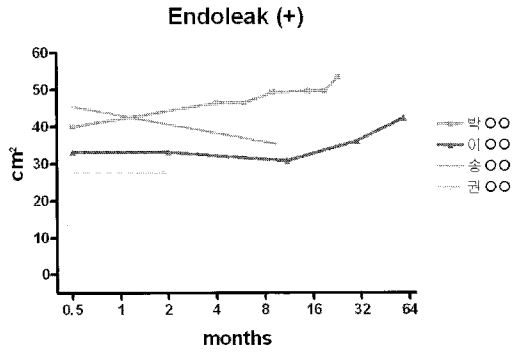

Figure 5. Size changes of aortic aneurysm during the follow-up period in 4 patients with endoleak positive after insertion of stent-graft.

The perioperative mortality of the endovascular management is similar to that of open surgery. There is also short-term benefit of stent-graft procedure. It may reduce the requirement of anesthesia, stress and blood loss. Stent-graft application is an effective endovascular treatment for aortic aneurysm. However, there can be a variety of complications after the procedure. The most important one is endoleak after stent-graft application [3-7]. In the cases without endoleak, there is high chance of decrease of aneurysm size. In the cases with false aneurysm such as in Behcet's disease, the aneurysm may regress completely with resorption of aneurysm and surrounding soft tissue mass[10]. However, the aneurysm may increase and eventually rupture in the cases with endoleak. Close observation with CT angiography is necessary for the evaluation for the presence of endoleak and size change.

In cases with successful procedure of stent-graft, the aneurysm will be completely excluded from the blood flow. There will be a thrombosis in the excluded aneurysm cavity. There will be no pressure transmission and no flow from the aortic lumen as the hemodynamic results of exclusion of aneurysm by stent-graft. There are various kinds of complications of the stent-graft application. Those are malpositioning, migration, perigraft leakage, kinking and tortuosity, fever, infection, and arterial embolism. These are related to technical factor inherent to the stent-graft materials and delivery system. Another factor is short learning curve. Post-implantation syndrome may appear in more than 50%, in which fever develops not responding to antipyretics

and the blood culture is negative. The mechanism is not clear yet but it is self-limited and lasts days to 3 weeks[3-7].

Among the complications, the endoleak is a condition which we can take care of. The reported range of the primary endoleak (before 30 days) is 5-44%. The endoleak on discharge was 14% in 895 patients of Eurostar Registry. New endoleak during the first year was 18%[11].

Type 1 endoleak is graft-related attachment failure. It is also related with a poor patient selection short neck or tortuous iliac artery. Other factors are inferior stent-graft characteristics, poor proximal & distal fixation, poor columnar support and inexperience with delivery. The proximal anastomotic endoleak should be resolved at an early stage to prevent a delayed aneurysmal rupture. Type 2 endoleak is a non-graft-related complication. It is due to perfusion of aneurysm sac by collateral vessels such as lumbar or inferior mesenteric artery. It may be occluded spontaneously but can be easily managed by occlusion with embolization of the collateral vessels. Type 3 endoleak is a junctional leak or modular disconnection or fabric disruption, which may be overcome by addition of a stent-graft into the portion. Type 4 endoleak is a graft porocity, which is usually temporary till 30 days after the procedure. Endotension, type 5, is a difficult situation to make a correct diagnosis. It is a condition with increase of aneurysm without evidence of endoleak or stent-graft abnormality. If the leak is less than 1ml/min, it may not be detected. Or a fresh thrombus may transmit pressure. In this case a rigorous search is recommended to detect any endoleak to treat it. If it is not evident open conversion is recommended [12].

The evaluation of size change after application of stent-graft can be done with CT angiography. In the untreated abdominal aneurysm the reported annual growth rate was 3.9mm/year. In the report of 73 patients with follow-up 3 to 30months after endografting the aneurysm decreased with rate of 0.34mm/month in the cases of negative endoleak[9].

In those cases with endoleak positive, we have to manage the situation with surgical conversion or endovascular techniques. In another report of 63 patients, the annual decrease of AAA diameter after endovascular repair was 8.4mm. Ten patients with successfully treated endoleak had a mean decrease in diameter of 11 mm per year[13].

In those cases with endoleak negative, we can expect a decrease of aneurysm size. In a report, 99 among 161 patients who did not exhibit an endoleak showed a significant decrease in aneurysm volume during the follow-up period. They suggested that the presence of a 10% or greater decrease in volume at 6 months predicts clinical success with freedom from endoleak[14].

However, if the size increases even though there is no evidence of endoleak, there is a possibility of endotension. In the case with endotension in our series, the aneurysm continued to grow while there was no evidence of endoleak after interventions with coil and glue embolizations. In patients with endotension, the pressure can be measured with direct puncture. Elevated sac pressure was found in all patients in one series. The sac pressure in patients with endoleak was found to be systemic or near systemic and all had pulsatile waveforms. Elevated sac pressures were also found in patients without evidence of endoleak by imaging[15-16]. In another report, the mean pressure index, percentage of mean intra-aneurysm pressure relative to aortic pressure, was 19% in shrinking (n=11), 30% in unchanged (n=10), and 59% in expanding (n=9) aneurysms without endoleaks. Pulse pressure was also higher in expanding (10mmHg) compared with shrinking (2mmHg) in the report[17]. The endotension is further to be investigated for the physiology of the excluded aneurysm and size change. In those cases with endotension, a surgical conversion is strongly recommended to prevent a delayed rupture.A new design for stent-graft is attempted with enhancement of proximal adhesion and full support of the graft. Recently branch endografting is attempted to expand the anatomic indication of the procedure. Small sensors for monitoring the contents of the aneurysm are also tested for the pressure or flow measurement after the stent-graft application.

As a conclusion, in the stent-graft application for aortic aneurysm, the aneurysm size is expected to decrease in cases with endoleak negative. However, the aneurysm may increase and eventually rupture in cases with endoleak positive. Close observation with CT angiography is necessary in patients with aortic aneurysm after stent-graft application for the evaluation of endoleak and aneurysm size change.

References

1. Chuter TAM. Anatomy of the infrarenal aortic aneurysm. In: Chuter TAM, Donayre CE, White RA, eds. Endoluminal vascular prostheses. Boston, New York, Toronto, London: Little, Brown and Company, 1995; 21-36
2. Pressler V, McNamara JJ. Thoracic aortic aneurysm: natural history and treatment. J Thorac Cardiovasc Surg 1980; 79:489-498
3. Parodi JC, Palmaz JC, Barona HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. Ann Vasc Surg 1991; 5:491-499
4. Blum U, Langer M, Spillner G, et al. Abdominal aortic aneurysms: preliminary technical and clinical results with transfemoral placement of endovascular self-expanding stent-grafts. Radiology 1996; 198:25-31
5. Murphy KD, Richter GM, Henry M, Encarnacion CE, Le VA, Palmaz JC. Aortoiliac aneurysms: management with endovascular stent-graft placement. Radiology 1996; 198:473-480
6. Leather RP, Shah DM, Goldman M, Rosenberg M, Karmody AM. Nonresective treatment of abdominal aortic aneurysm. Arch Surg 1979; 144:1402-1404
7. Moritz JD, Rotermund S, Keating DP, Oestmann JW. Infrarenal abdominal aortic aneurysms: implications of CT evaluation of size and configuration for placement of endovascular aortic grafts. Radiology 1996; 198:463-466
8. White RA, Donayre CE, Walot I, Woody J, Kim N, Kopchok GE Computed tomography assessment of abdominal aortic aneurysm morphology after endograft exclusion. J Vasc Surg. 2001 Feb;33(2 Suppl):S1-10.
9. Wolf YG, Hill BB, Rubin GD, Fogarty TJ, Zarins CK Rate of change in abdominal aortic aneurysm diameter after endovascular repair. J Vasc Surg. 2000 Jul;32(1):108-115.
10. Park JH, Chung JW, Joh JH, Song SY, Shin SJ, Chung KS, Lee DY, Kim SJ. Aortic and arterial aneurysm in Behcet's disease: management with stent-graft – initial experience. Radiology 2001; 22-:745-750
11. Harris PL, Vallabhaneni SR, Desgranges P, Becquemin JP,van Marrewijk C, Laheij RJ. Incidence and risk factors of later rupture, conversion, and death after endovascular repair of infrarenal aortic aneurysms: the EUROSTAR experience. European Collaboration on Stent/graft techniques for aortic aneurysm repair. J Vasc Surg 2000;32:739-749
12. Veith FJ, et al. Nature and significance of endoleaks and endotension: Summary of opinions expressed at an international conference. J Vasc Surg 2002; 35:1029-1035
13. Farner MC, Carpenter JP, Baum RA, Fairman RM. Early changes in abdominal aortic aneurysm diameter after endovascular repair. J Vasc Interv Radiol 2003; 14:205-210
14. Lee JT, Aziz IN, Lee JT, et al. Volume regression of abdominal aortic aneurysms and its relation to successful endoluminal exclusion. J Vasc Surg 2003; 38:1254-1263
15. Baum RA, Carpenter JP, Cope C, et al. Aneurysm sac pressure measurements after endovascuar repair of abdominal aortic aneurysms. J Vasc Surg 2001; 33:32-41
16. Schurink GW, et al. Experimental study of the influence of endoleak size on pressure in the aneurysm sac and the consequences of thrombosis. Br J Surg 2000; 87:71-78
17. Dias NV, Ivancev K, Malina M, Rescn T, Lindblad G, Sonesson B. Intra-aneurysm sac pressure measurements after endovascular aneurysm repair: differences between shrinking, unchanged, and expanding aneurysms with and without endoleaks. J Vasc Surg 2004; 39:1229-1235